Original Article

MEDICINE PALLIATIVE CARE

DOI: 10.47582/jompac.1447357

J Med Palliat Care. 2024;5(2):135-143

Pre-operative pulmonary risk assessment in surgery patients

Gülhan Ayhan Albayrak, Mustafa İlteriş Bardakçı, Arzu Müfide Özkarafakılı

Department of Chest Diseases, Şişli Hamidiye Etfal Training and Research Hospital, İstanbul, Turkiye

Cite this article as: Ayhan Albayrak G, Bardakçı Mİ, Özkarafakılı AM. Pre-operative pulmonary risk assessment in surgery patients. *J Med Palliat Care*. 2024;5(2):135-143.

Received: 05.03.2024 ◆ **Accepted**: 28.04.2024 ◆ **Published**: 30.04.2024

ABSTRACT

Aims: Postoperative pulmonary complications (PPC) that may develop after surgery are important causes of morbidity and mortality. PPCs cause a prolongation of hospital stays and an increase in hospitalization costs. The study aims to determine factors associated with PPCs to predict PPCs in surgical patients undergoing preoperative evaluation.

Methods: A retrospective cohort study was conducted at Şişli Hamidiye Etfal Training and Research Hospital using data from 200 patients referred for preoperative pulmonary evaluation from anesthesia and surgery clinics. This study analyzed the characteristics and outcomes of patients with PPC and those without PPC. The Canet pulmonary risk scores are used for PPC in all preoperative surgery patients. The study's primary endpoints are to determine the development of respiratory failure, bronchospasm/asthma, COPD exacerbation, atelectasis, pleural effusion, or pneumonia. The study also analyzed the effective respiratory function parameters for PPC development using a logistic regression model.

Results: The total study population included 200 patients with a median age of 53.5 years (aged between 19-88), 103 (51.5%) of whom were female. PPCs were observed in 38% (n=76) of the study group. There was a statistically significant difference between the patients in terms of the development of postoperative pulmonary complications according to gender (higher in males, p=0.001) and smoking (p=0.0001). Preoperative oxygen saturation (SpO2) and FEV1/FVC ratio were significant predictors of PPC development, and complications were more frequent in low-saturated patients (p=0.0001, p=0.013 respectively). The relationship between SpO2 and PPC was confirmed via logistic regression analysis. A one-unit increase in saturation reduced the occurrence of postoperative respiratory complications by 0.645-fold. The cut-off value for the saturation value was 97.5%, with a sensitivity of 46.8% and a specificity of 71.1% [p=0.0001, 95% CI, (0.521-0.798)].

Conclusion: In this study, the Canet (ARISCAT) score, a preoperative evaluation scale validated in Turkey that predicts postoperative pulmonary complications and mortality, was used. The Canet risk score is a simple risk score with moderate discriminatory performance for predicting PPCs. It may be useful in identifying individual patients at high risk of PPC and in the design of future studies to evaluate interventions to prevent these complications. However, a customized preoperative risk assessment system is needed for each patient.

Keywords: Preoperative pulmonary evaluation, postoperative pulmonary complication, surgical patients, pulmonary risk, Canet (ARISCAT) scoring

INTRODUCTION

Postoperative pulmonary complications (PPC) are important causes of morbidity and mortality. PPCs cause a prolongation of hospital stays and an increase in hospitalization costs.[1] Possible strategies to identify high-risk patients in the preoperative period, have been investigated. Modifiable risk factors should be evaluated to minimize postoperative complications. In the preoperative period anesthetic evaluation is aimed at detecting and treating patients at risk for the development of complications; hence, consultation with a pulmonologist will surely decrease morbidity and mortality.[2]

To pre-determine the risk of complications and mortality in patients who undergo surgery, preoperative evaluation should determine the factors that cause deterioration in pulmonary functions in the perioperative period. PPCs are usually the result of significant deterioration of pulmonary function due to surgery itself, anesthesia, or pharmacological applications.[3] The most important postoperative complications are respiratory failure, acute exacerbations of Chronic Obstructive Pulmonary Disease (COPD), pulmonary thromboembolism, pneumonia, prolonged mechanical ventilation, and atelectasis.[4]

Atelectasis, pneumonia, respiratory failure, and tracheobronchial infection can be listed among the main PPCs. The most common postoperative complication is atelectasis. The primary cause of mortality has been reported

Corresponding Author: Gülhan Ayhan Albayrak, dr.gulhanayhan@hotmail.com

This work is licensed under a Creative Commons Attribution 4.0 International License.

as pneumonia. In addition, revealing the potential risk factors for pulmonary complications enables the prediction of complications by determining preventive strategies for these patients. In previous studies, preoperative risk factors for the development of PPC were investigated for specific surgical groups, such as upper abdominal interventions[5], esophagectomy[6], and total knee arthroplasty.[7]

Pulmonary complications are frequently seen postoperatively in patients due to multifactorial causes. The surgical intervention, the anesthesia method, and the preoperative risk factors of the patients play an important role. The risk factors associated with demographic characteristics and anesthesia include obesity, smoking, age, comorbidities, and the effectiveness of postoperative pain treatment, as well as the type and duration of anesthesia. The surgical risk factors include the duration of the intervention, the surgical technique, and the size of the incision.

We used the Canet scoring system (Figure 1) and PFTs (pulmonary function tests) data in the Assessment of Respiratory Risk in Surgical Patients in our hospital. The factors in the Canet scoring system include age, preoperative arterial oxygen saturation in the air, acute respiratory infection in the previous month, preoperative anemia, upper abdominal or intrathoracic surgery, duration of surgery, and emergency surgical intervention.[9]

Independent predictors of risk for PPCs		Risk score
Age, years		
≤ 50		0
51–80		3
> 80		16
Preoperative SpO_2, %		
≥ 96%		0
91–95%		8
≤ 90%		24
Respiratory infection in the last month		
No		0
Yes		17
Preoperative anemia (HbO_2 ≤ 10 g/dl)		
No		0
Yes		11
Surgical incision		
Peripheral		0
Upper abdominal		15
Intrathoracic		24
Duration of surgery, hours		
≤ 2		0
2–3		16
> 3		23
Emergency procedure		
No		0
Yes		8
Risk class	Number of points in risk score	Pulmonary complications rates
Low risk	<26 points	1.6%
Intermediate risk	26–44 points	13.3%
High risk	≥45 points	42.1%

PPC postoperative pulmonary complications

Figure 1. ARISCAT (Canet) risk index[9]

Our study shows that gender, smoking status, comorbidities, respiratory symptoms like dyspnea, findings from respiratory exams like expiratory rhonchus, respiratory function exams (preoperative oxygen saturation, SpO2), and pulmonary function tests (PFT) can all help figure out if someone will have a PPC. The aim of the study is to show how accurate these tests can be.

Our study aims to identify all factors that may affect the development of PPCs in surgical patients and minimize pulmonary risk by predicting PPC during the preoperative period. Additionally, clinic also uses the Canet scoring system and respiratory system evaluation tests, like preoperative SpO2 and PFT parameters, to figure out the pulmonary risk before surgery in people who already have respiratory diseases or who have just been diagnosed with respiratory diseases. We aim to reduce the risk of PPC by implementing effective pulmonary improvement approaches.

METHODS

Ethical Considerations

All procedures were followed by the ethical standards of the responsible committee on human experimentation (institutional and national) and the Helsinki Declaration of 1975, as revised in 2008. Ethics committee approval was granted from Şişli Hamidiye Etfal Training and Research Hospital Clinical Researches Ethics Committee (Date: 06.09.2022, Decision No: 2144). As this was retrospective research, no informed consent was obtained from participants.

Study Population

Between January 1, 2022, and August 1, 2022, our Chest Diseases outpatient clinic examined 200 patients who were referred for preoperative pulmonary evaluation from the anesthesia and surgical clinics at Health Sciences University Şişli Hamidiye Etfal Hospital.

Inclusion criteria: Patients over the age of 18, regardless of gender, male or female, who underwent surgical intervention or surgical treatment and who requested a preoperative pulmonary evaluation were included in the study.

Exclusion criteria: Patients under 18 years of age, patients who were not suitable for preoperative pulmonary evaluation, and patients with psychiatric diseases were not included in the study.

Study Design

A retrospective cohort study was conducted at Şişli Hamidiye Etfal Hospital using data from 200 patients who were referred for preoperative pulmonary evaluation from anesthesia and surgery clinics. The patients were divided into two groups for the study. Group 1 comprised individuals who did not develop any PPCs, while Group 2 comprised those who did. The analysis was carried out on patients with complete data files. As this was a retrospective study, we did not obtain any consent forms from the patients.

The postoperative period was considered to be 1 week. Canet pulmonary risk scores were used to evaluate the risk of PPCs in all preoperative surgery patients (Figure 1). The Canet scoring system factors that we use for the assessment

of respiratory risk in surgical patients in our hospital were recorded. The scores were obtained from the hospital's electronic database.

Data Collection

As part of this study, we analyzed the data of 200 patients who were assessed at the Şişli Hamidiye Etfal Training & Research Hospital Pulmonology Outpatient Clinic between January 1, 2022, and August 1, 2022. The data of patients is gathered from their files and also from the hospital's database. Information such as the patient's age, gender, chronic conditions, symptoms, duration, lab results, treatments, readmissions, ongoing symptoms, hospitalizations, ICU admissions, and mortality was documented in the case follow-up form.

The Canet pulmonary risk scores (low arterial oxygen saturation before surgery, recent acute respiratory infection, age, anemia before surgery, upper abdominal or intrathoracic surgery, surgery lasting at least 2 hours, and emergency surgery) and admissions to the intensive care unit were looked at in the past. The primary endpoint of the study was to evaluate PPC, which includes respiratory failure, bronchospasm or asthma, acute COPD exacerbation, atelectasis, pleural effusion, or pneumonia The study's secondary endpoints were comparisons of ICU admission rates and 1-month mortality rates between patients with and without PPCs. A prediction index was created that determines the respiratory function parameters (SpO2 and PFT) that are effective in predicting the development of PPC (logistic regression prediction model).

Statistical Analysis

The IBM SPSS 26.0 package program was used in the statistical analysis of the study. Descriptive statistics (frequency, percentage, mean, standard deviation, etc.) of the patients in the study were calculated. The Chi-square test was used for categorical data, the independent samples t-test, or the Mann-Whitney U test was used for continuous (numerical) data based on the normal distribution status. These tests were used to compare demographic data, clinical features, PFT results, and Canet risk classification results based on the status of having respiratory complications after surgery. Receiver Operating Characteristic (ROC) curves were used to evaluate the predictive ability of preoperative SpO2, Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV1), and FEV1/FVC rates for postoperative PPCs in each diagnostic group. Logistic regression analysis was conducted to determine the factors influencing PPC development. Cut-off values were computed to identify the risk factors associated with each variable, including risk score, PFT results, and saturation levels, on PPCs. All statistical analyses were evaluated at the 95% confidence interval, and significance was evaluated at the $p<0.05$ level.

RESULTS

Basic Characteristics

The total study population included 200 patients. The demographic characteristics of patients are shown in Table 1. The mean age in Group 1 (PPC negative, n=124) was 59.4±15.4 years (range 19-85 years), and in Group 2 (PPC positive, n=76), mean age was 62.51±13.8 years (range 19-88 years). While the groups were similar in terms of age distribution and mean age ($p>0.05$). PPCs were not detected in 75 (60.5%) female patients in Group 1, whereas they were detected in 48 (63.2%) male patients in Group 2. The gender distribution between the groups with PPC (positive) and without PPC (negative) showed a statistically significant difference ($p<0.001$). Group 1 (PPC-negative) had a higher proportion of non-smokers (59 patients, 47.6%) compared to Group 2 (PPC-positive), and in Group 1 there are more ex-smokers (42 patients, 55.3%). This comparison suggests non-smoking is a significant factor in preventing PPCs. There was a difference in the prevalence of gastrointestinal (GI) disease between the groups, with 14 patients (11.3%) in Group 1 (PPC-negative) and 1 patient (1.3%) in Group 2 (PPC-positive). However, this difference was not statistically significant.

Table 1. The comparisons of the demographic characteristics of PPC (-) and PPC (+) groups

	Postoperative Pulmonary complication		p
	Group 1 PPC(-) (n=124)	Group 2 PPC(+) (n=76)	
Age	59.4±15.4	62.51±13.8	0.188
≤50	31 (25)	15 (19.7)	0.391
51-80	85 (68.5)	54 (71.1)	0.709
>80	8 (6.5)	7 (9.2)	0.472
Gender			
Male	49 (39.5)	48 (63.2)	0.001**
Female	75 (60.5)	28 (36.8)	0.001**
Smoking status			
Smoker	30 (24.2)	19 (25)	0.898
Non-smoker	59 (47.6)	15 (19.7)	0.0001**
Ex-smoker	35 (28.2)	42 (55.3)	0.0001**
Comorbidities disease			
No	6 (4.8)	5 (6.6)	0.6
Cancer	19 (15.3)	19 (25)	0.09
HT	17 (13.7)	7 (9.2)	0.342
HD	7 (5.6)	7 (9.2)	0.337
GISD	14 (11.3)	1 (1.3)	0.009**
COPD	14 (11.3)	16 (21.1)	0.061
Asthma	29 (23.4)	11 (14.5)	0.126
DM	3 (2.4)	1 (1.3)	1
Other	15 (12.1)	9 (11.8)	0.957

*:p<0.05; **: P<0.01, PPC: Postoperative pulmonary complications, PPC (-): Without Postoperative pulmonary complications, PPC (+): with Postoperative pulmonary complications, HT: Hypertension, HD: Heart disease, GISD: Gastrointestinal system Disease, COPD: Chronic Obstructive Pulmonary Disease, DM: Diabetes mellitus

The clinical features of patients are shown in Table 2. Preoperative respiratory symptoms were significantly more frequent in Group 2 (PPC positive) compared to Group 1 (PPC negative) (77.6% vs. 20.2%, p=0.002). Preoperative SpO2 was measured preoperatively, with an average of 96.78±1.7. The majority of patients (82.5%, n=165) had SpO2 levels at or above 96%. SpO2 reflects the oxygen level in your blood and can be an indicator of potential respiratory problems.

Table 2. The comparisons of the clinical features of PPC (-) and PPC (+) groups

	Postoperative Pulmonary complication		p
	Group 1 PPC(-) (n=124)	Group 2 PPC(+) (n=76)	
Respiratory symptoms			
Normal	25 (20.2)	4 (5.3)	0.004**
Dyspnea	70 (56.5)	59 (77.6)	0.002**
Chest pain	19 (15.3)	11 (14.5)	0.87
Cough	10 (8.1)	2 (2.6)	0.116
Physical examination findings			
Normal	26 (21)	0 (0)	0.0001**
Expiratory rhonchi	10 (8.1)	23 (30.3)	0.0001**
Expiration was prolonged	45 (36.3)	28 (36.8)	0.937
Breath sounds were coarse	41 (33.1)	21 (27.6)	0.42
Reduced breath sounds	2 (1.6)	4 (5.3)	0.203
Preoperative SPO2 (%)	97.2± 1.1	96.09± 2.2	0.0001**
<90%	0 (0)	5 (6.6)	0.007**
%91-95	10 (8.1)	20 (26.3)	0.0001**
≥96%	114 (91.9)	51 (67.1)	0.0001**
Preoperative anemia hemoglobin (g/dl)	12.65± 2	12.53± 2.4	0.904
≤10 g/dl	14 (11.3)	15 (19.7)	0.1
>10 g/dl	110 (88.7)	61 (80.3)	0.1
Prior diagnosis of pulmonary diseases			
Yes	47 (37.9)	48 (63.2)	0.001**
No	77 (62.1)	28 (36.8)	0.001**
Newly diagnosed pulmonary diseases			
Yes	34 (27.4)	46 (60.5)	0.0001**
No	90 (72.6)	30 (39.5)	0.0001**

**: p<0.01, PPC: Postoperative Pulmonary complications, Preoperative SPO2 (%): Preoperative oxygen saturation, PPC (-): Without Postoperative pulmonary complications, PPC (+): with Postoperative pulmonary complications

PPC patients are shown in Table 3. As you can see, respiratory failure was the most common PPC, affecting 34.2% (n=26) of patients with PPCs. Atelectasis (27.6%, n=21) and COPD/asthma attacks (21%, n=16) were also relatively frequent. Pneumonia (13%, n=10), bronchospasm (2.6%, n=2), and other complications (1.3%, n=1) were in group 2 patients. Overall, PPCs were observed in 76 out of 200 patients (38%).

Table 3. Distribution of PPCs for all patients

Variables (n=200)	n (%)
No	124 (62)
Atelectasis	21 (10.5)
Pneumonia	10 (5)
Respiratory failure	26 (13)
COPD or asthma attack	16 (8)
Bronchospasm	2 (1)
Other	1 (0.5)

COPD: Cronic Obstructive Pulmonary Disease, PPC: Postoperative Pulmonary complication

Table 4 shows PPCs according to PFT results. Preoperative SpO2 and the ratio of Forced Expiratory Volume in One Second (FEV1) to Forced Vital

Table 4. The comparisons of the PFT Results of PPC (-) and PPC (+) groups

PFT	Postoperative Pulmonary Complication		p
	Group 1 PPC(-) (n=117)	Group 2 PPC(+) (n=69)	
FVC	77.07±23.5	74±21.5	0.376
Normal (≥70%)	76 (65)	38 (55.1)	0.213
Abnormal (< 70)	41 (35)	31 (44.9)	
FEV1	76.33±25.3	70.12± 20.7	0.086
Normal (> 80)	54 (46.2)	22 (31.9)	0.146
Mild obstruction (60-80)	35 (29.9)	28 (40.6)	
Abnormal (<60)	28 (23.9)	19 (27.5)	
FEV1/FVC	81.1±12.2	77.25±12th	0.013*
Normal (≥70%)	102 (87.2)	51 (73.9)	0.029*
Abnormal (<70)	15 (12.8)	18 (26.1)	

*: p<0.05, PPC: Postoperative pulmonary complication, PFT: Pulmonary function test, FEV1: Forced expiratory volume in one second, FVC: Forced vital capacity, PPC (-): Without postoperative pulmonary complications, PPC (+): With postoperative pulmonary complications

Capacity (FVC) were also important indicators of PPC development. Complications were more common in people who were not fully saturated (p=0.0001, p=0.013, respectively). (FEV1: Forced Expiratory Volume in One Second; FVC: Forced Vital Capacity).

Table 5 shows PPCs according to the results of the Canet classification. Individuals with higher pulmonary risk scores (≥45) had an increased risk of PPC (p=0.0001).

Table 6 shows the effect of SpO2, FEV1/FVC ratio, and Canet risk score on PPC. Logistic regression analysis was

Table 5. The comparisons of risk factors for postoperative pulmonary complications PPCs between CANET classification PPC (-) and PPC (+) groups

	Postoperative Pulmonary Complication		p
	Group 1 PPC (-) (n=124)	Group 2 PPC (+) (n=76)	
Pulmonary risk score	29.57± 13.7	52.72± 12.4	0.0001**
Low (below 26 points)	47 (37.9)	0 (0)	
Medium (26-44 points)	64 (51.6)	16 (21.1)	0.0001**
High (45 points and above)	13 (10.5)	60 (78.9)	

**: p<0.01, PPC: Postoperative pulmonary complication, PPC (-): Without postoperative pulmonary complications, PPC (+): With postoperative pulmonary complications

used to find the risk factors (SpO2, FEV1/FVC ratio, and Canet risk score) that are effective in the development of PPCs. The relationship between SpO2 and PPC was confirmed through logistic regression analysis (p=0.0001). A one-unit increase in SpO2 reduced the risk of postoperative respiratory complications by 0.645 times result was confirmed via logistic regression analysis (95% CI, 0.645 (0.521 to 0.798; p=0.0001). A one-unit increase in the Canet risk score increases the risk of PPCs 1.143 fold (95% CI, 1.143 (1.101 to 1.185; p=0.0001). The relationship between the FEV1/FVC ratio and PPC was confirmed via logistic regression analysis (95% CI: 0.95-0.999; p=0.037), A one-unit increase in the FEV1/FVC value reduces the risk of PPCs by 0.974 times.

Table 7 shows the cut-off value for postoperative pulmonary complications of the Canet risk score, FEV1/FVC, and SpO_2 for postoperative respiratory complications. The cut-off value for the SpO2 value was 97.5%, with a sensitivity of 46.8% and a specificity of 71.1% (p=0.0001).The cut-off value for Canet risk score scores was 42.5, with a sensitivity of 81.6% and a specificity of 81.5%, which is statistically significant (p=0.0001). The cut-off value for the FEV1/FVC ratio was 81.5%, with a sensitivity of 55.6% and a specificity of 58.0%, achieving statistical significance (p=0.013).

DISCUSSION

Our study revealed that certain factors contribute to the development of PPCs, such as gender, smoking, and comorbid diseases (such as GIS disease). From our analysis of demographic data, shortness of breath emerged as a significant respiratory symptom, while expiratory rhonchi were highlighted as a key finding during the examination. Additionally, preoperative SpO2 values, as well as a previous diagnosis of respiratory system disease, were identified as potential risk factors for PPCs. In addition, our study showed that newly diagnosed respiratory system diseases can also increase the likelihood of developing PPCs.

Among the 200 patients, 38% (n=76) developed at least one PPC within the first month, with respiratory failure (13%, n=26) being the most common, followed by atelectasis (10.5%, n=21). Notably, 26 patients suffered from respiratory failure and 21 from atelectasis. We classified them separately because, even though atelectasis can contribute to respiratory failure, they are distinct conditions.

Table 6. The effect of CANET risk score, of FEV1/FVC, of SpO_2 on PPC

	χ^2	p (Model)	-2 Log likelihood		R^2	
Canet risk score	107.299	<0.0001**	158.327		0.565	
Postoperative pulmonary complication	**B**	**Standard Error**	**Wald**	**Sd**	**p**	**Exp(B) CI**
Risk score	0.133	0.019	50.838	1	0.0001**	1,143 (1,101-1,185)
Constant	-6.040	0.837	52.041	1	0.0001**	0.002
FEV1/FVC	4.343	0.037*	240.979		0.032	
Postoperative respiratory complication	**B**	**Standard Error**	**Wald**	**Sd**	**p**	**Exp(B) CI**
EV1/FVC	**-0.026**	**0.013**	**4.230**	**1**	**0.04***	**0,974 (0,95-0,999)**
Constant	**1.540**	**1.013**	**2.313**	**1**	**0.128**	**4.666**
Preoperative SpO_2	21.043	0.0001**	244.582		0.136	
Postoperative respiratory complication	B	Standard Error	Wald	Sd	p	**Exp(B) CI**
SpO_2	-0.439	0.109	16.190	1	0.0001**	0.645 (0,521-0,798)
Constant	41.992	10.565	15.797	1	0.0001**	1.725

PPC: Postoperative pulmonary complication, SpO2 (%): Preoperative oxygen saturation, FEV1: Forced Expiratory Volume in One Second, FVC: Forced Vital Capacity, Confidence Intervals (CI)

Table 7. The cut-off value for PPC of CANET risk score, of FEV1/FVC, of SpO2 on PPC

Risk Factor (PPC)	AUC (%)	Cut off	p	Sensitivity (%)	Specificity (%)
CANET risk score	0.892 (0.848;0.937)	42.5	0.0001**	81.6%	81.5%
FEV1/FVC	0.609 (0.525;0.693)	81.5	0.013*	55.6%	58.0%
Preoperative SpO_2	0.656 (0.576;0.736)	97.5	0.0001**	46.8%	71.1%

PPC: Postoperative pulmonary complication, SpO2 (%): Preoperative oxygen saturation, FEV1: Forced Expiratory Volume in One Second, FVC: Forced Vital Capacity

In a study conducted by Su H. et al.[10], the development of PPC was associated with prolonged hospital stays. These results may show that the development of PPC will prolong the length of stay in the hospital, as well as that prolonged hospitalization may lead to the development of PPC. Previous studies have shown that PPCs such as pulmonary embolism, atelectasis, pneumonia, and respiratory failure prolong the length of stay in the hospital. The results and PPCs obtained in our study are the results of the first 7 days after surgery.

PPCs like pneumonia and atelectasis are major concerns after surgery. They can significantly worsen a patient's condition by causing dyspnea, requiring additional oxygen support, and potentially leading to respiratory failure. This not only increases morbidity, or the likelihood of experiencing negative health effects, but can also raise mortality risk. Additionally, PPCs often necessitate extended hospital stays, placing a strain on healthcare resources and increasing costs.[11] Pulmonary complications increase the length of stay in the hospital, the need for prolonged mechanical ventilation, or a predisposition to secondary infections. Diaphragm movements are restricted, and bronchial mucociliary activities decrease during the intubated period of the patients. Petrar et al.[12] and Sogame et al.[13] reported that PPCs not only prolong the length of hospital stay but also increase the rate of patient admission to the intensive care unit. It has been reported that atelectasis is the most common postoperative pulmonary complication.[14]

Examination of postoperative complications reveals that pneumonia, respiratory failure (indicated by oxygen demand), bronchospasm, atelectasis, and pleural effusion are among the most frequent and concerning issues encountered. These complications can significantly prolong hospital stays, increase healthcare costs, and worsen patient outcomes. [15] In a study conducted by Ko E. et al.[15], the importance of pulmonary complaints in the preoperative period was proven to be similar to the data previously published in the literature. The risk of developing postoperative complications increases in patients with preoperative cough, sputum, and dyspnea complaints.

When the postoperative period (30 days) data were examined, the low, medium, and high-risk scoring system of Canet et al.[16] was applied in our study, and its usefulness was demonstrated. Preoperative smoking cessation has been shown to result in longer-term cessation at a higher rate than smoking cessation at other times.[17] In our study, gender (being male) and active smoking were found to have clinically significant effects on the risk of PPC.

Those who have had an upper respiratory tract infection in the last month before the operation are more likely to develop PPC. Perioperative smokers have an increased risk of major morbidity and mortality, including 30-day PPC, surgical site infection, ICU hospitalization, wound complications, neurological complications, and septic shock.[18,19] In the study by Bluman et al.[20], postoperative pulmonary complications were more common in smokers.

Two observational studies evaluating PPC rates using pulmonary function tests like FVC and the FEV1/FVC ratio found a significant correlation. Patients with lower FVC and FEV1/FVC had a higher incidence of PPCs. This suggests that lower pulmonary function might be a risk factor for developing PPCs[21,22] Wong et al.[23] investigated 105 patients undergoing cardiothoracic surgery with severe chronic obstructive pulmonary disease (defined as FEV1<1.2 L and FEV1/FVC ratio <75%). In their cohort, an FEV1/FVC ratio of less than 50% constituted one of the five independent risk factors. Three other independent factors (abdominal surgery, ASA class IV or V, and general anesthesia) provided higher odds ratios in the multivariate model.[24] In another study of 460 patients undergoing abdominal surgery, FEV1<61%, FEV1 between 61 and 79%, the presence of ischemic heart disease, undergoing cancer surgery, and age were each identified as independent risk factors. The strongest single factor is FEV1<61%.[25]

When the results of our study were examined, the FEV1/FVC ratio was an essential predictor of PPC development, and complications were higher in low-saturated patients (p=0.013). Table 6, Table 7, and Figure 2, Figure 3, and Figure 4 show the relationship between the FEV1/FVC ratio and PPC, which was confirmed via logistic regression analysis (p=0.037). A one-unit increase in FEV1/FVC value reduces the occurrence of PPCs by 0.974 fold.

This 10-year study at Lille University Hospital investigated ventilation parameters and their association

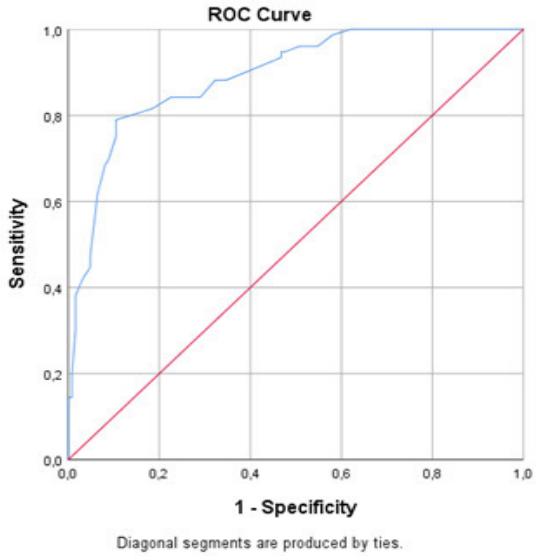

Figure 2. ROC curve CANET risk score on postoperative pulmonary complication (ROC Analyse)

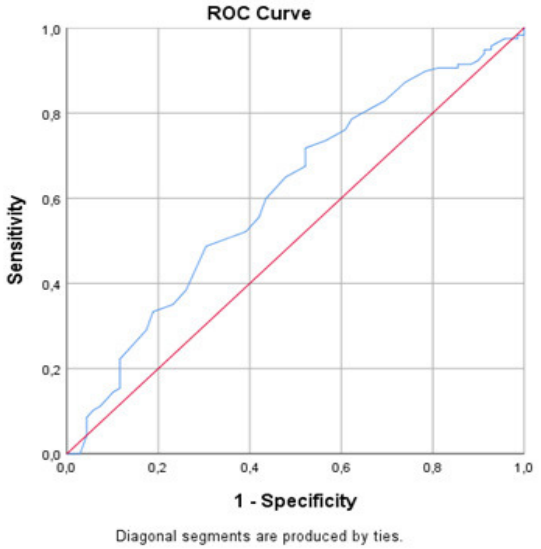

Figure 3. ROC curve value FEV1/FVC on postoperative pulmonary complication (ROC Analyse)

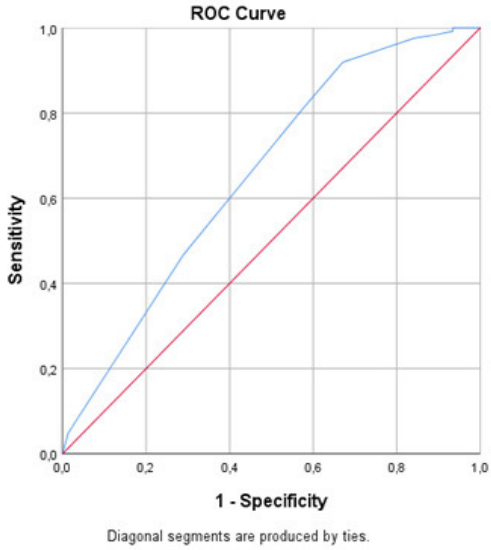

Figure 4. ROC curve value SpO2 on postoperative pulmonary complication (ROC Analyse)

with PPC development. These included lower estimated body weight, lower expiratory tidal volume (the amount of air exhaled with each breath during mechanical ventilation), reduced dynamic respiratory system compliance (the lungs' ability to expand and contract), and higher estimated mechanical power (likely referring to the work required by the ventilator to move air). Also, things that happened during surgery, like SpO2 levels below 96% and ETco2 levels dropping, were found to be independent predictors of PPCs.[26]

Limitations

The findings of our study have some limitations. Firstly, since our study was retrospective and observational, our study was designed with the data in the patient file. Therefore, no data other than these could be added to our study. Second, the sample size was insufficient, which may require a larger cohort for more robust statistical analyses. Thirdly, since there is no standard scoring and evaluation system for each pulmonologist in preoperative pulmonary evaluation, the potential for bias exists due to each expert's experience.

CONCLUSION

In our study, various factors such as gender, smoking status, comorbidities, respiratory symptoms (ex. dyspnea), respiratory examination findings (ex. expiratory rhonchus), prior diagnosis of pulmonary diseases, newly diagnosed pulmonary diseases, and respiratory function examinations (preoperative SpO2 and PFT measurements) are examined to determine how effective and reliable they can be in predicting PPCs.

At the same time, we used the Canet risk scoring method, which has been previously validated in Turkey, to estimate the risk of PPCs. This scoring system helps determine preoperative risks in patients who wish to receive treatment in Chest Disease outpatient clinics. Our study concluded that the Canet scoring method, using PFT parameters, is an effective tool for preoperative evaluation and risk prediction, especially in estimating the risk of PPC and mortality.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Şişli Hamidiye Etfal Training and Research Hospital Clinical Researches Ethical Committee (Date: 06.09.2022, Decision No. 2144).

Informed Consent

As this was retrospective research, no informed consent was obtained from participants.

Referee Evaluation Process
Externally peer-reviewed.

Conflict of Interest Statement
The authors have no conflicts of interest to declare.

Financial Disclosure
The authors declared that this study has received no financial support.

Author Contributions
All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

Proofreading and Editting
The English translation of this article has undergone proofreading and editing.

REFERENCES

1. Jha AK, Jha N, Malik V. Perioperative decision-making in pulmonary hypertension. *Heart Lung Circ*. 2023;32(4):454-466. doi: 10.1016/j.hlc.2023.01.013.
2. Rajagopal S, Ruetzler K, Ghadimi K, et al. Evaluation and management of pulmonary hypertension in noncardiac surgery: a scientific statement from the American Heart Association. *Circulation*. 2023;147(17):1317-1343. doi: 10.1161/CIR.0000000000001136.
3. Yoon U, Topper J, Goldhammer J. Preoperative evaluation and anesthetic management of patients with liver cirrhosis undergoing cardiac surgery. *J Cardiothorac Vasc Anesth*. 2022;36(5):1429-1448. doi: 10.1053/j.jvca.2020.08.022.
4. Machino R, Shimoyama K, Nagayasu T, Tagawa T. Preoperative inhalation therapy for patients with chronic obstructive pulmonary disease undergoing lung surgery: a retrospective study. *J Cardiothorac Surg*. 2022;17(1):294. doi: 10.1186/s13019-022-02042-y. PMID: 36434678.
5. Haines KJ, Skinner EH, Berney S, The Austin Health POST Study Investigators. Association of postoperative pulmonary complications with delayed mobilisation following major abdominal surgery: an observational cohort study. *Physiotherapy*. 2013;99(2):119-125.
6. D'Annoville T, D'Journo XB, Trousse D, Brioude G, Dahan L, Seitz JF. Respiratory complications after oesophagectomy for cancer do not affect disease-free survival. *Eur J Cardiothorac Surg*. 2012;41(5):e66-e73.
7. Ryu YJ, Chun EM, Shim SS, Kim JS, Kim YH. Risk factors for pulmonary complications, including pulmonary embolism, after total knee arthroplasty (TKA) in elderly Koreans. *Arch Gerontol Geriatr*. 2010;51(3):299-303.
8. Li L, Yang Q, Guo Q, Liu D, Gao H, Liu Y. Preoperative physical performance predicts pulmonary complications after coronary artery bypass grafting: a prospective study. *Sci Rep*. 2022;12(1):11103. doi: 10.1038/s41598-022-15145-2.
9. Yan T, Liang XQ, Wang T, et al. Prophylactic penehyclidine inhalation for prevention of postoperative pulmonary complications in high-risk patients: study protocol of a randomized controlled trial. *Trials*. 2017;18(1):571. doi: 10.1186/s13063-017-2315-7.
10. Su H, Zhang J, Liu Y, Peng H, Zhang L. Pre and postoperative nurse-guided incentive spirometry versus physiotherapist-guided pre and postoperative breathing exercises in patients undergoing cardiac surgery: an evaluation of postoperative complications and length of hospital stay. *Medicine*. 2022;101(52):e32443. doi: 10.1097/MD.0000000000032443.
11. Ganescu O, LaRusso K, St-Louis E, et al. The utility of echocardiography and pulmonary function testing in the preoperative evaluation of pectus excavatum. *J Pediatr Surg*. 2022;57(8):1561-1566. doi: 10.1016/j.jpedsurg.2021.12.010.
12. Petrar S, Bartlett C, Hart RD, MacDougall P. Pulmonary complications after major head and neck surgery: a retrospective cohort study. *Laryngoscope*. 2012;122(5):1057-1061.
13. Sogame LC, Vidotto MC, Jardim JR, Faresin SM. Incidence and risk factors for postoperative pulmonary complications in elective intracranial surgery. *J Neurosurg*. 2008;109(2):222-227.
14. Smetana GW. Postoperative pulmonary complications: an update on risk assessment and reduction. *Cleve Clin J Med*. 2009;76(4):S60-S65.
15. Ko E, Yoo KY, Lim CH, Jun S, Lee K, Kim YH. Is atelectasis related to the development of postoperative pneumonia? a retrospective single center study. *BMC Anesthesiol*. 2023;23(1):77. doi: 10.1186/s12871-023-02020-4.
16. Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiol*. 2010;113(6):1338-1350. doi: 10.1097/ALN.0b013e3181fc6e0a.
17. Shi Y, Warner DO. Surgery as a teachable moment for smoking cessation. *J Am Soci Anesthesiologists*, 2010;112(1):102-107.
18. Turan A, Mascha EJ, Roberman D, et al. Smoking and perioperative outcomes. *Anesthesiol*. 2011;114(4):837-846. doi: 10.1097/ALN.0b013e318210f560.
19. Grønkjær M, Eliasen M, Skov-Ettrup LS, et al. Preoperative smoking status and postoperative complications: a systematic review and meta-analysis. *Ann Surg*. 2014;259(1):52-71. doi: 10.1097/SLA.0b013e3182911913.
20. Bluman LG, Mosca L, Newman N, Simon DG. Preoperative smoking habits and postoperative pulmonary complications. *Chest*. 1998;113(4):883-889. doi: 10.1378/chest.113.4.883.
21. Kispert J, Kazmers A, Roitman L. Preoperative spirometry predicts perioperative pulmonary complications after major vascular surgery. *Am Surgeon*. 1992;58(8):491-495.
22. Gerson MC, Hurst JM, Hertzberg VS, Baughman R, Rouan GW, Ellis K. Prediction of cardiac and pulmonary complications related to elective abdominal and noncardiac thoracic surgery in geriatric patients. *Am J Med*. 1990;88(2):101-107. doi: 10.1016/0002-9343(90)90456-n.
23. Wong DH, Weber EC, Schell MJ, Wong AB, Anderson CT, Barker SJ. Factors associated with postoperative pulmonary complications in patients with severe chronic obstructive pulmonary disease. *Anesth Analg*. 1995;80(2):276-284. doi: 10.1097/00000539-199502000-00013.

24. Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med*. 2006;144(8):581-595. doi: 10.7326/0003-4819-144-8-200604180-00009.

25. Fuso L, Cisternino L, Di Napoli A, et al. Role of spirometric and arterial gas data in predicting pulmonary complications after abdominal surgery. *Respir Med*. 2000;94(12):1171-1176. doi: 10.1053/rmed.2000.0946.

26. Elefterion B, Cirenei C, Kipnis E, et al. Intraoperative mechanical power and postoperative pulmonary complications in noncardiothoracic elective surgery patients: a 10-year retrospective cohort study. *Anesthesiol*. 2024;140(3):399-408. doi: 10.1097/ALN.0000000000004848.